Ocean Heat and Freshwater Storage and Transports in Observations and Climate Models

Matt Palmer (MetOffice, UK)

- Explore the use of observation-based estimates of large-scale ocean heat and freshwater transport and storage in model evaluation, assessment and development.

- Assess the current capability of the ocean observing system to measure ocean heat and freshwater transport and storage changes, including budget constraints at global and regional scales to identify priority areas for new observations.

- Assess CMIP6 models fitness-for-purpose in diagnosing forced heat and freshwater changes, including: global and regional conservation of ocean heat and freshwater; systematic model biases; model representation of regional heat/freshwater budgets.

Workshop had been organzied in 2020 – but finally cancelled…. (postponed until October 2021)

Organizing Committee

Matt Palmer (OOPC/Met Office Hadley Centre)
Karina von Schuckmann (Mercator Ocean International)
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Lijing Cheng (IAP, Chinese Academy of Sciences)
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Bernadette Sloyan (CSIRO)
Neil Swart (Environment Canada / CliC)
Amy Solomon (CU/NOAA/NORP)

Workshop Sessions

Theme 1: Estimates of large-scale ocean heat and freshwater storage and transports from observations and models

- Heat and freshwater transport and storage in Earth System models, reanalyses and observations: assessment and priority areas for improvement
- Large-scale regional budgets of heat and freshwater - how can we improve closure?
- The role of climate variability in regional budgets and changes in heat/freshwater transport and storage
- Developing a community-led set of priority model metrics for large-scale heat and freshwater storage/transports and observational targets based on the current ocean observing system

Theme 2: Assessment of the global ocean observing system – approaches, results and recommendations

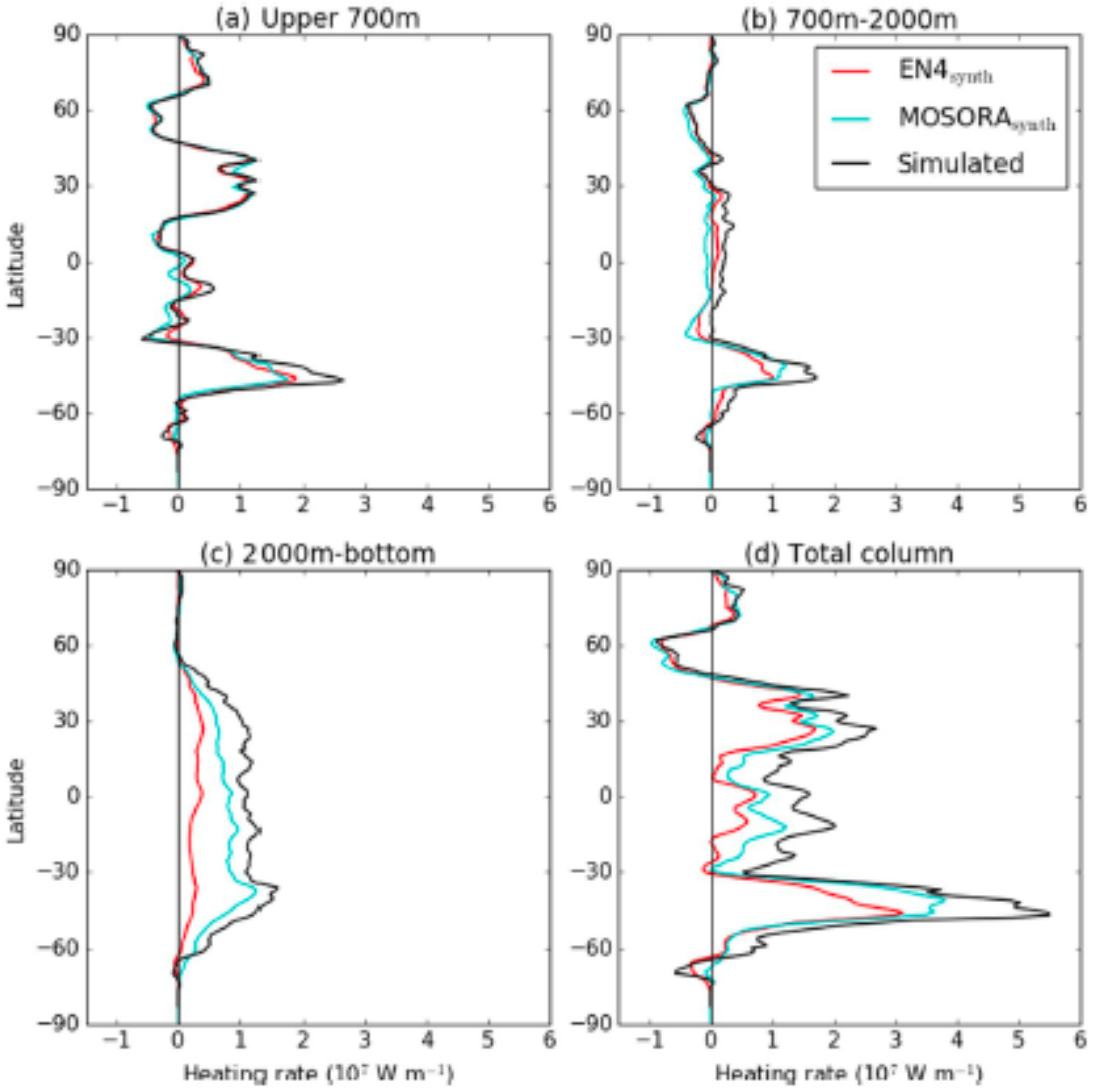
- Models as test beds for the observing system, using “synthetic observations” and other approaches.
- Developing a community view on priorities for future ocean observations that would reduce uncertainties in key process understanding and aid climate model evaluation and development
- Towards “case study” papers on the use of synthetic observations for observing system assessment and estimating uncertainties in global and regional indicators of climate change and implications for future observing system design.

Theme 3: CMIP6 models fitness-for-purpose in diagnosing forced heat and freshwater changes in a global and regional context

- Heat and freshwater conservation in CMIP6: where are we now and what are the outstanding challenges?
- Regional heat/freshwater budget studies and observational comparisons to better understand and address long-standing model biases in climate models
- Development of model metrics for heat/freshwater conservation, budgets and storage to inform CMIP7 protocol.

Towards quantifying uncertainty in ocean heat content changes using synthetic profiles (Allison et al., 2019)

https://iopscience.iop.org/article/10.1088/1748-9326/ab2b0b



Allison et al. (2019)

CONCEPT:

- mapping methods used to interpolate sparse ocean temperature profile data are a key source of uncertainty
- new approach to assessing OHC mapping methods using ‘synthetic profiles’
- generated from a state-of-the-art global climate model simulation.
- Synthetic profiles have the same sampling characteristics as the historical ocean temperature profile data but are based on model simulation data.
- Mapping methods ingest these data in the same way as they would real observations, but the resultant mapped fields can be compared to a model simulation ‘truth’

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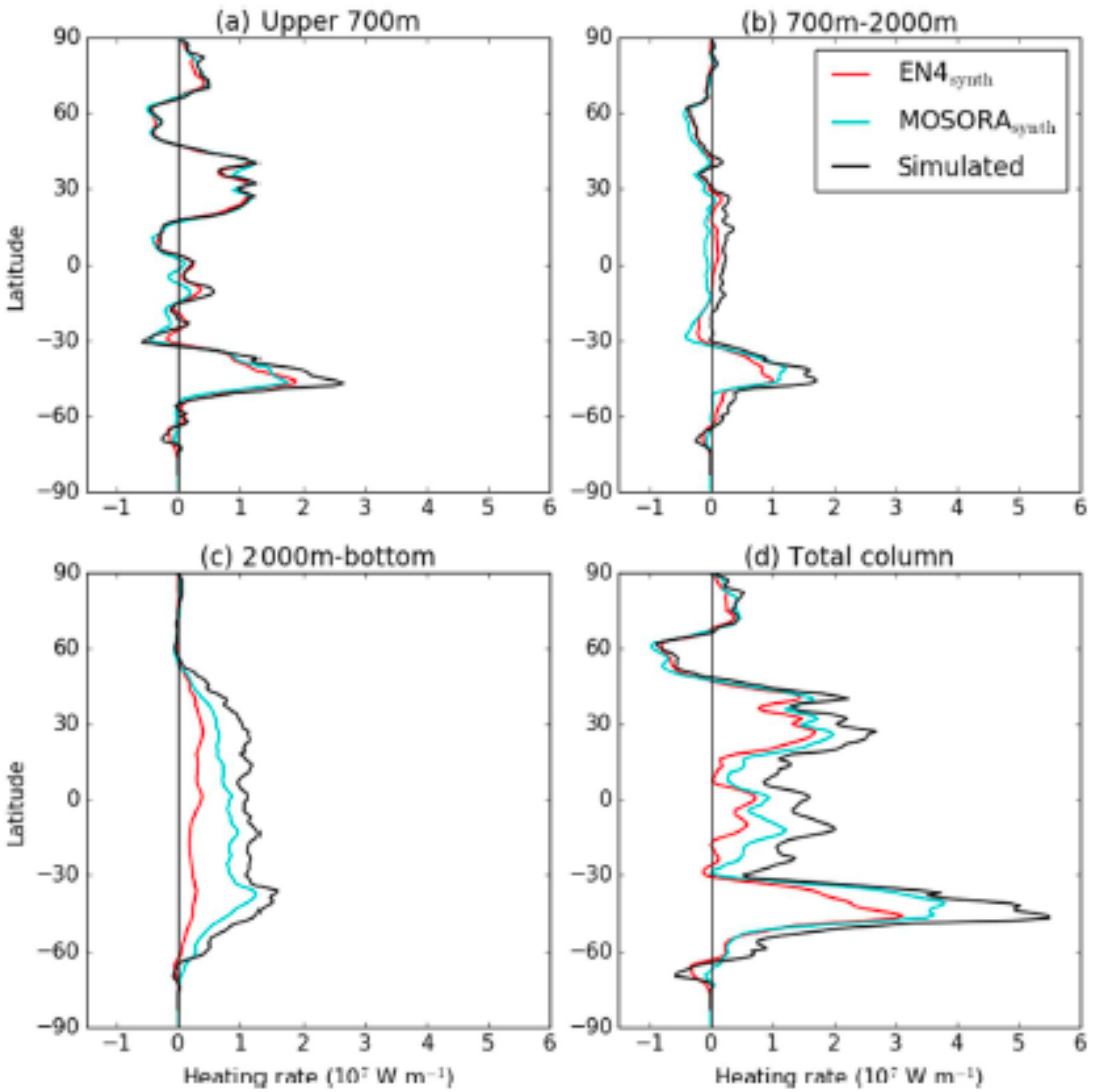
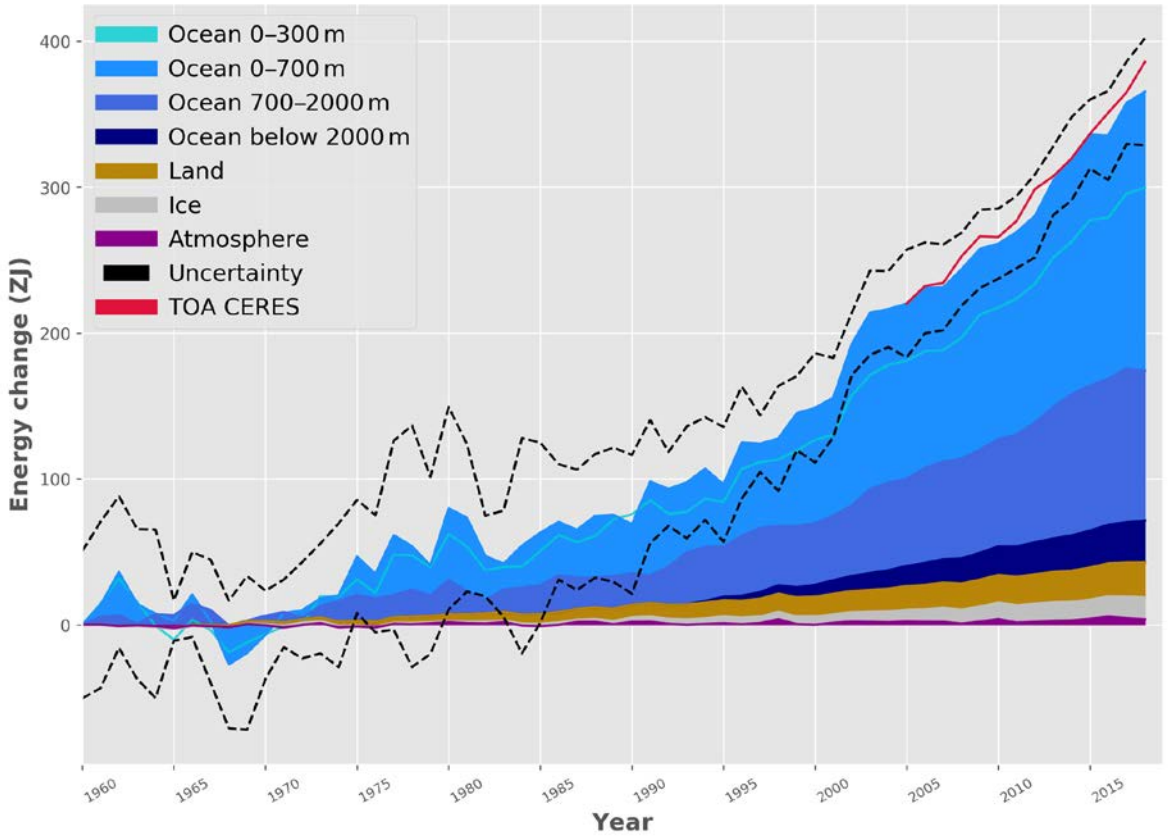


Allison et al. (2019)

RESULTS:

- Argo network of autonomous profiling floats drives clear improvements in the ability to reconstruct the variability and spatial structure of OHC changes.
- 2000 m, magnitude of the simulated ocean warming signal is underestimated.
- Temporal variability and trends in OHC are better captured in the northern hemisphere than in the southern hemisphere due to sampling differenences.
- At all depths, the sampling characteristics of the historical data introduces some spurious variability in the estimates of globa lOHCon sub-annual to multiannual timescales.
- However,many of the large scale spatial anomalies, especially in the upper ocean, are successfully reconstructed even with sparse observations from the 1960s

Heat stored in the Earth system: where does the energy go? von Schuckmann et al. (2020)
https://essd.copernicus.org/articles/12/2013/2020/

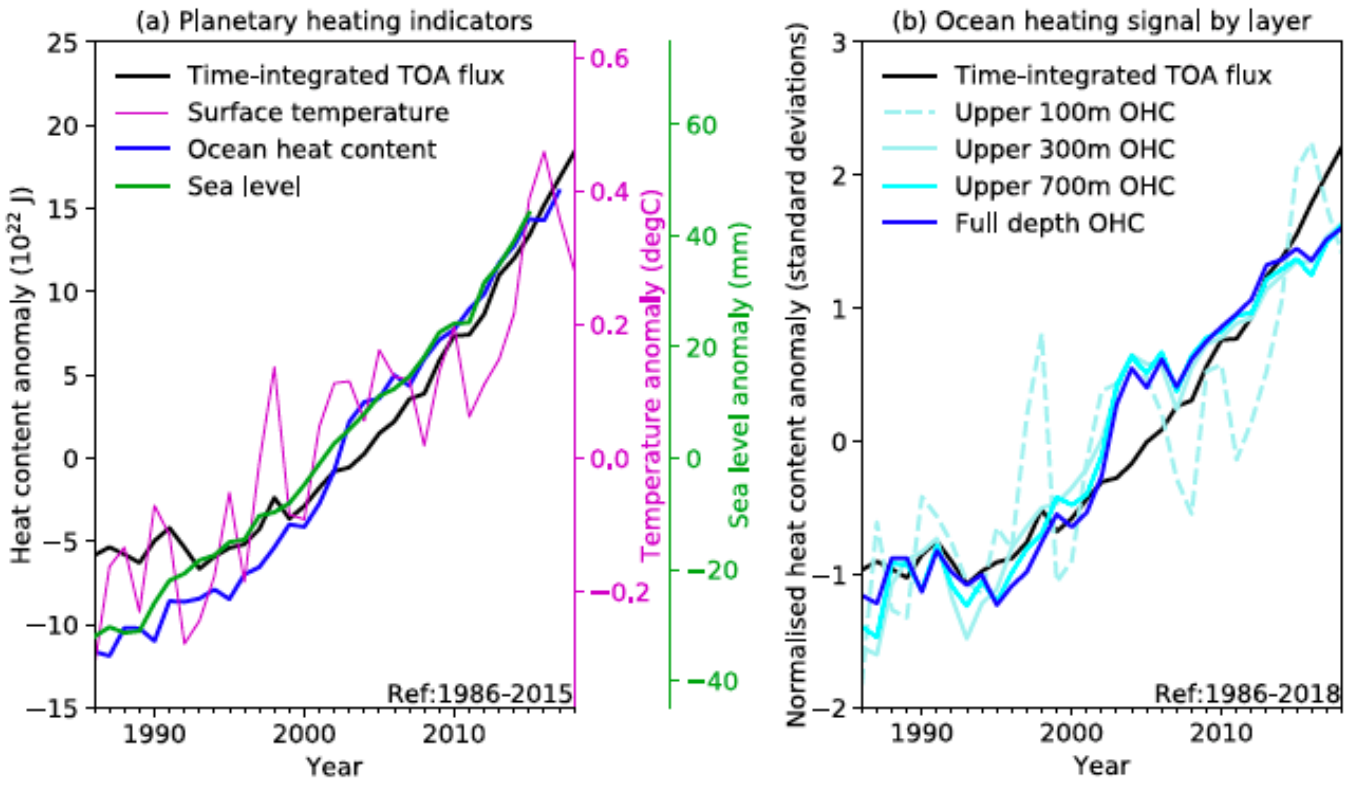


Evaluation of the Earth heat inventory based on

- new assessment of global ocean heta content based on 15 different international estimates
- updated evaliuation of land heat content based on borehole measurements
- updated estimate of atmospheric heat content based on a combined use of atmospheric reanalysis & remote sensing data
- new estimate of heat available to melt ice based on a combined use of model, reanalysis, in situ and remote sensing data

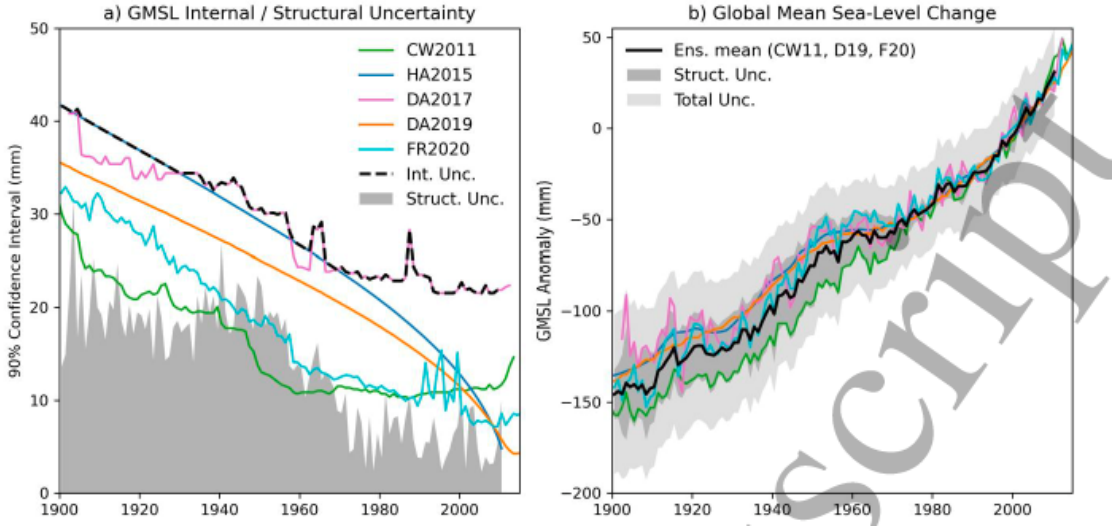
GLOBAL CLIMATE OBSERVING SYSTEM
KEEPING WATCH OVER OUR CLIMATE
WMO
IOC
International Science Council
UN environment

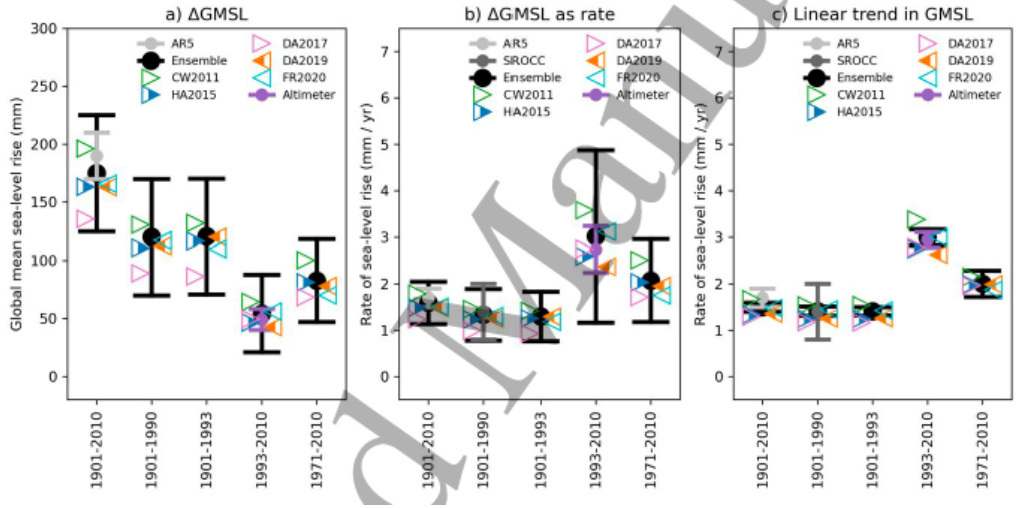
Allison et al (2020) "Observations of planetary heating since the 1980s from multiple independent datasets"
https://iopscience.iop.org/article/10.1088/2515-7620/abbb39



- Study based on multiple datasets that span the past~30 years.
- finding supports that global ocean heat content and sea level are more reliable than surface temperature for monitoring Earth's energy accumulation on these timescales.
- Global ocean temperature anomalies in the 0–100m and
- 100–250 m layers are negatively correlated, primarily explained by the influence of the
- Tropical Pacific, and a clearer heating signal is revealed by integrating over deeper ocean layers.
- The striking agreement between multiple independent datasets represents unequivocal evidence of ongoing planetary heating.

Palmer et al (2021) [an ensemble framework for quantifying changes in climate indicators, with GMSL as an example] "**An ensemble approach to quantify global mean sea-level rise over the 20th century from tide gauge reconstructions**"
https://iopscience.iop.org/article/10.1088/1748-9326/abdaec/meta





Ensemble approach to quantify historical GMSL rise based on tide gauge reconstructions

- Combines the maximum internal uncertainty across the ensemble with an estimate of structural uncertainty to provide a conservative estimate of the total uncertainty.
- Comparisons of GMSL rise over the 20th century based on their respective uncertainties are consistent with past IPCC assessments and show good agreement with satellite altimeter timeseries.
- Sensitivity tests show their estimates of GMSL rise are robust to the choice of reference period and central estimate timeseries.
- The methods proposed in this study are generic and could be easily applied to other global or regional climate change indicators

➔ **Please contact Matt Palmer for more information on this activity.**